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AUTHOR Wooley, John F.
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ABSTRACT

A commonly used test for determining filterability of conditioned sludge is the specific resistance (Buchner funnel) test. The sludge is filtered through filter paper using a Buchner funnel, and the time needed to obtain a given volume of filtrate (or for cake residue to begin to crack) is measured. The shorter the time, the better the filterability of the sludge. Designed for individuals who have completed National Pollutant Discharge Elimination System (NPDES) level 1 laboratory training skills, this module provides waste water treatment plant operators with the basic skills and information needed to: (1) successfully run the specific resistance test; (2) accurately record data and observations; (3) organize data to perform required calculations; (4) make general interpretations as to the quality of sludge utilized in the test based on values obtained; and (5) obtain reliable, consistent results from the test procedure. The instructor's manual contains a statement of instructional goals, lists of instructor/student activities and instructional materials, overhead transparency masters, and student worksheet (with answers). The student workbook contains objectives, prerequisite skills needed before the module is started, laboratory procedures, and worksheet. (Author/JN)

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Operational Control Tests
for Wastewater Treatment Facilities

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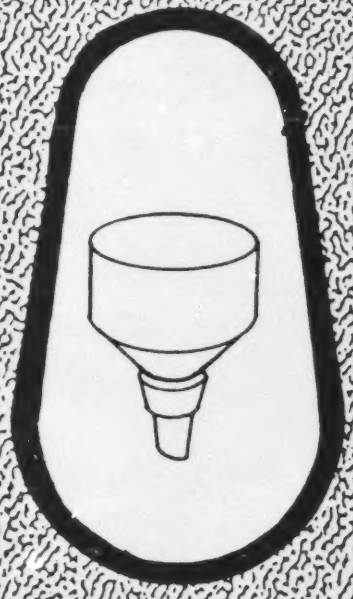
Specific Resistance

Instructor's Manual



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Linn-Benton Community College
Albany, Oregon

SPECIFIC RESISTANCE TEST

Written By:
John F. Wooley
Linn-Benton Community College
Albany, Oregon

Instructional Design:
Priscilla Hardin
Corvallis, Oregon

Project Management:
John W. Carnegie, Ph.D.
Linn-Benton Community College
Albany, Oregon

Project Officer:
Lynn S. Marshall
United States Environmental Protection Agency
National Training and Operational Technology Center
Cincinnati, Ohio

Developed Under:
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August, 1981

SPECIFIC RESISTANCE TEST

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INSTRUCTIONAL GOALS

Upon completion of this lesson the student should be able to successfully run the specific resistance test and accurately record the data and observations. The student also should be able to organize the data so as to perform the required calculations for this test. Based on values obtained the student should be able to make general interpretations as to the quality of sludge utilized in the test.

INSTRUCTOR ACTIVITY

For best results follow this sequence:

	Activity	Time
1.	Review the procedural objectives with the students.	5 minutes
2.	Have the students read the procedure.	10 minutes
3.	Demonstrate the test procedure.	15 minutes
4.	Discuss calculations.	15 minutes
5.	Assign worksheet.	5 minutes
6.	Correct worksheet.	10 minutes
7.	Perform test.	30 minutes
8.	Perform calculations and make interpretations.	20 minutes

OTHER ACTIVITIES

1) Prepare filters.
2) Using visual aids, i.e. overhead projections, clarify the type of information needed for the calculations.
3) Have students calculate specific resistance and other pertinent parameters based on precollected test data. Other parameters include percent solids and percent moisture.

STUDENT ACTIVITY

1. Read objectives.
2. Read procedure.
3. Complete worksheet.

4. Perform test.
5. Record data.
6. Calculate percent solids, percent moisture, and specific resistance.
7. Interpret results.

INSTRUCTIONAL MATERIALS LIST

1. Instructor's Guide - Specific Resistance
2. Student Workbook - Specific Resistance
3. Overhead projector
4. Projector screen
5. Equipment listed in the Lab Procedures

OH #1 - Specific Resistance Apparatus

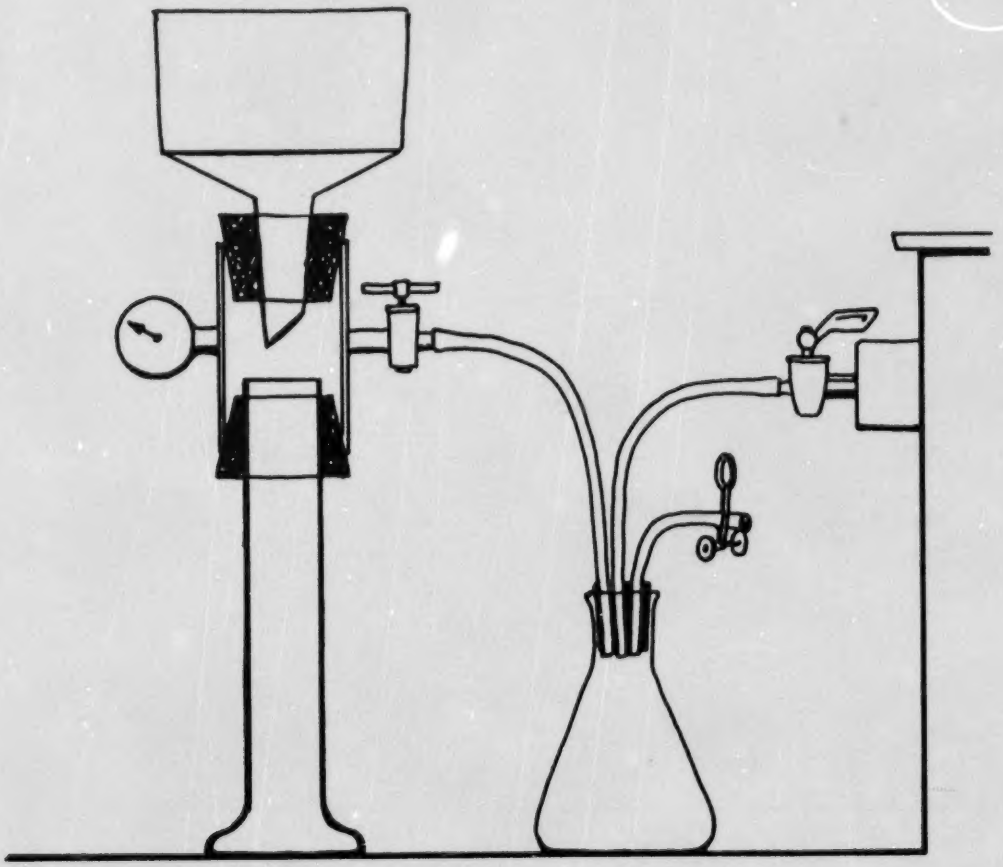
OH #2 - Use this overhead to explain the data sheet and to point out where the various pieces of data should be entered. You may wish to refer back to OH #1 as you proceed through the calculation of specific resistance.

OH #3 - Use to explain calculation of percent solids in conditioned sludge.

OH #4 - Use to explain calculation of percent solids in filter cake.

OH #5 - Use to explain calculation slope of the T/V vs. V plot.

OH #6 - Use to explain the final specific resistance calculation.



SPECIFIC RESISTANCE APPARATUS

OH #2

Specific Resistance Test Data

Sample Date_____ Analysis Date_____

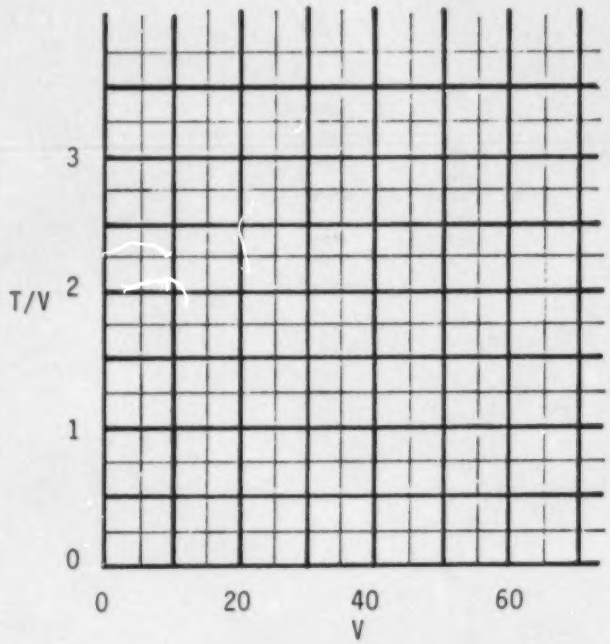
Sample Location_____ Lab Technician_____

Sludge Type_____ Conditioner:Type_____ Amount_____

CONDITIONED SLUDGE	
A) Wt. Dish plus Wet Sludge,g	
B) Wt. Dish plus Dry Sludge,g	
C) Wt. of Dish,g	
D) Wt. of Wet Sludge,g (A - C)	
E) Wt. of Dry Sludge,g (B - C)	
(Cs) % Solids in Sludge (E/D x 100)	
100 - Cs	

FILTER CAKE	
Sample Vol., ml	
F) Sample Wt.,g	
G) Wt. Filter plus Cake,g	
H) Wt. of Filter,g	
I) Wt. of Cake,g (G - H)	
(Cf) % solids in Cake (I/F x 100)	
100 - Cf	

T Time, sec	V Filtrate vol.ml	T/V
10		
20		
30		
40		
50		
60		



Slope $\frac{T/V}{V}$ = _____

$$\text{Specific Resistance} = \frac{\text{slope} \times 61{,}628{,}672}{\frac{1}{\frac{100 - Cs}{Cs} - \frac{100 - Cf}{Cf}}} = \text{_____ Sec}^2/\text{g}$$

PERCENT SOLIDS IN CONDITIONED SLUDGE (C_s)

$$C_s = \frac{\text{wt. of dry sludge, g}}{\text{wt. of wet sludge, g}} \times 100$$

PERCENT SOLIDS IN FILTER CAKE (C_f)

$$C_f = \frac{\text{wt. of cake, g}}{\text{wt. of sample, g}} \times 100$$

CALCULATE SLOPE

$$\text{SLOPE}, \frac{T/V}{V} = \frac{\text{time/volume}}{\text{volume}}$$

OH #6

CALCULATE SPECIFIC RESISTANCE

$$SR = \frac{\text{slope} \times 61{,}628{,}672}{\dfrac{1}{\dfrac{100 - Cs}{Cs} - \dfrac{100 - Cf}{Cf}}}$$

Sr-9 of 9

4/82

SPECIFIC RESISTANCE TEST

WORKSHEET

Directions: Place an "X" by the best answer. There is only one best answer for each question.

1. The major purpose for the specific resistance test is to:

   a)_____ determine SVI.

   b)__X__ measure filterability of sludge.

   c)_____ determine decant time.

   d)_____ None of the above.

   e)_____ All of the above.

2. Calculation of slope:

   a)_____ has no bearing in the calculation of specific resistance.

   b)__X__ is the relationship of time/volume per volume.

   c)_____ is a function of cake solids.

   d)_____ None of the above.

   e)_____ All of the above.

3. Calculation of slope:

   a)__X__ is necessary for the calculation of specific resistance.

   b)_____ is necessary for the calculation of percent moisture.

   c)_____ is necessary in the calculation of percent solids.

   d)_____ None of the above.

   e)_____ All of the above.

4. In general, it can be stated that the faster a sludge dewaters:

   a)_____ the lower the solids concentration.

   b)_____ the higher the solids concentration.

   c)_____ the better the filterability of the sludge.

   d)_____ None of the above.

   e)_____ All of the above.

5. When running a specific resistance test:

a)_____ the time interval is 30 seconds.

b)_____ the time interval is one hour.

c)__X__ time has no bearing except to determine slope.

d)_____ None of the above.

e)_____ All of the above.

6. Specific resistance test results are given in:

a)_____ cc/l.

b)_____ ppm.

c)_____ mg/l.

d)__X__ Sec^2/g.

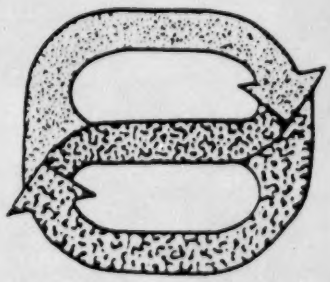
e)_____ mg/g.

Operational Control Tests

for Wastewater Treatment Facilities

Specific Resistance

Student Workbook



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SPECIFIC RESISTANCE TEST

Written By:
John F. Wooley
Linn-Benton Community College
Albany, Oregon

Instructional Design:
Priscilla Hardin
Corvallis, Oregon

Project Management:
John W. Carnegie, Ph.D.
Linn-Benton Community College
Albany, Oregon

Project Officer:
Lynn S. Marshall
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SPECIFIC RESISTANCE TEST

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INTRODUCTION

This instructional package on specific resistance is intended to give the operator the basic information necessary to obtain reliable, consistant results from the test procedure.

The mention of any brand names should not be taken as an endorsement of that equipment or supplies.

This instructional package is intended to be used by students who have completed the NPDES Level I laboratory skills training.

OBJECTIVES

Upon completion of this instructional package you should be able to:

1. Describe the purpose of the specific resistance test.
2. Recall that the test gives results in Sec^2/g.
3. Describe the apparatus used in the test.
4. Describe the test procedure.
5. Perform the test procedure.
6. Calculate appropriate values from the data collected.

PREREQUISITE SKILLS

In addition to the skills listed in the introduction the following skills are needed for this test:

1. Familiarity with the use of an analytical balance.
2. Ability to use a timer clock.
3. Ability to plot data.

SPECIFIC RESISTANCE TEST

INTRODUCTION

One of the very commonly used tests for determining filterability of conditioned sludge is the specific resistance (Buchner funnel) test. The sludge is filtered through a filter paper using a Buckner funnel and time to obtain a given volume of filtrate, or for the cake residue to begin to crack is measured. The shorter this time interval, the better the filterability of the sludge.

EQUIPMENT

Drying oven
Vacuum source
Dessicator
Vacuum flask
Vacuum hose
1 liter sample container
9 cm Buchner funnel with stopper
Collar with vacuum gauge and valve
100 ml graduated cylinder
3-hole stopper to fit vacuum flask
250 ml beaker
Timer
Whatman #4 filter paper
Analytical balance
Plastic wash bottle
Muslin mat for Buchner funnel

PRELIMINARY PROCEDURE

1. WASH FILTERS.

   Using a plastic wash bottle with distilled water, wet the filter while applying a gentle vacuum. Use three washes of about 20 ml each.

2. DRY FILTERS.

   For one hour in a 103° C drying oven.

3. STORE FILTERS IN DESSICATOR.

   After they have been washed and dryed, the filters may be stored in a desiccator until needed.

PROCEDURE

1. REMOVE FILTERS FROM DESICCATOR.

   Use forceps.

2. WEIGH FILTERS.

   Record the weights of the filters to four decimal places.

3. PLACE FUNNEL ON COLLAR.

   Place Buchner funnel on collar.

4. ATTACH COLLAR.

   Attach collar to 100 ml graduated cylinder.

5. CONNECT VACUUM SOURCE.

   Connect vacuum source to vacuum flask.

6. ATTACH VACUUM LINE.

   Attach vacuum line to collar and vacuum flask.

7. PLACE MUSLIN CLOTH MAT IN BUCHNER FUNNEL.

8. SEAT FILTER.

   After weighing filters place two 9 cm filters in the Buchner funnel making sure all the holes in the funnel are covered. Wet the filters with distilled water and seat by applying vacuum. Apply 40 cm (15.75 inches of Hg) vacuum to mat and filter.

9. DISCARD LIQUID.

   Discard the liquid collected in the 100 ml graduated cylinder from the seating procedure.

10. RE-ATTACH COLLAR TO 100 ml GRADUATED CYLINDER.

11. MEASURE SAMPLE.

    Measure 100 grams of conditioned sludge and place in a 250 ml beaker.

12. ADD SAMPLE AND START TIMER.

    On a portion of the conditioned sludge run a percent solids test. (See procedure in Supplementary Materials) Pour the conditioned sludge into the Buchner funnel and apply vacuum and start timer. Apply 40 cm (15.75 inches of Hg) vacuum to mat and filter.

13. MEASURE FILTRATE VS. TIME.

    Measure filtrate at 10 second intervals.

14. MEASURE TIME FOR CAKE TO CRACK.

15. WEIGH FILTER PLUS CAKE.

    Weigh filter plus cake and record to the fourth decimal place in grams.

CALCULATIONS

1. Calculate Percent Solids in Conditioned Sludge (Cs)

$$Cs = \frac{\text{wt. of dry sludge, g}}{\text{wt. of wet sludge, g}} \times 100$$

Example:

A) Wt dish plus wet sludge, g = 192.4282 g

B) Wt dish plus dry sludge, g = 94.2533 g

C) Wt of dish, g = 88.0423 g

D) Wt of wet sludge, g (A - C) = 192.4282 g - 88.0423 = 104.3859 g

E) Wt of dry sludge, g (B - C) = 94.2533 g - 88.0423 g = 6.2110 g

$$Cs = \frac{E}{D} \times 100$$

$$Cs = \frac{6.2110\ g}{104.3859\ g} \times 100 = 5.95\%$$

2. Calculate Percent Solids in Filter Cake (Cf)

$$Cf = \frac{\text{Wt. of Cake, g}}{\text{Wt. of Sample, g}} \times 100$$

Example:

F) Sample wt., g = 100.0000 g

G) Wt. Filter plus cake, g = 27.1953 g

H) Wt. of Filter, g = 0.6093 g

I) Wt. of Cake, g = 26. 5860 g

$$Cf = \frac{I}{F} \times 100$$

$$= \frac{26.5860\ g}{100.0000\ g} \times 100 = 26.59\%$$

3. Determine Slope from plotted data:

$$\text{Slope} = \frac{T/V}{V} = \frac{\text{Time/Volume}}{\text{Volume}}$$

Example:

At time of 30 seconds, Volume equals 47 ml

$$\text{Slope} = \frac{T/V}{V}$$

$$= \frac{30/47}{47}$$

$$= 0.0136$$

4. Calculate specific resistance:

$$\text{Specific Resistance} = \frac{\text{Slope} \times 61{,}628{,}672}{\frac{1}{\frac{100 - Cs}{Cs} - \frac{100 - Cf}{Cf}}}$$

Example:

$Cs = 5.95\%$

$100 - Cs = 94.05\%$

$Cf = 26.59\%$

$100 - Cf = 73.41\%$

$\text{Slope} = 0.0136$

$$\text{Specific Resistance} = \frac{0.0136 \times 61{,}628{,}672}{\frac{1}{\frac{94.05}{5.95} - \frac{73.41}{26.59}}}$$

$= 10{,}869{,}701$

$= 10^7 \ \text{Sec}^2/\text{g}$

INTERPRETATION

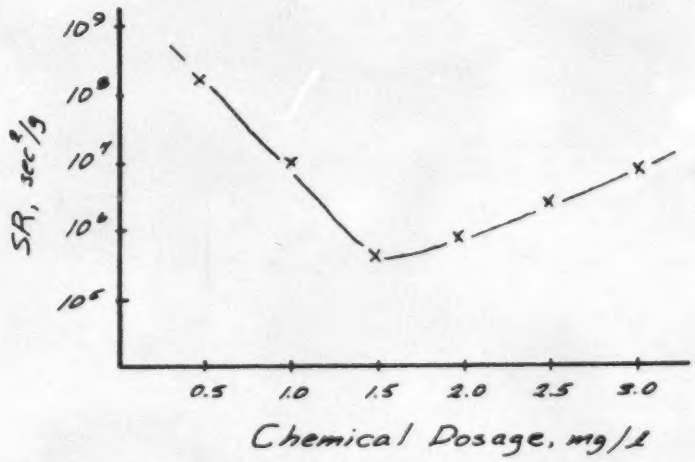
In general, it can be stated that the faster a sludge dewaters (the shorter the time to obtain a given volume of filtrate) the better the filtrability of the sludge.

A second indicator of sludge filterability is the duration of time needed for the cake to begin to crack. Again, the general interpretation is that the shorter the time interval the more filtrable the sludge. In both of the above cases there is a range where this interpretation is reliable. Too short of time intervals or too long could indicate problems with the sludge. Experience with the process unit you are working with will dictate these limits.

In general, sludge cakes that have higher % solids are a result of a more filtrable sludge. Also lower % moisture in the cake would indicate a superior sludge. If the percent moisture recovered is high this would indicate a sludge that dewaters more readily.

All aspects of this test should be used to predict what conditioning is more effective for a given sludge.

A series of specific resistance tests can be run on sludge treated with various doses of chemical conditioners. Specific resistance is plotted against chemical concentration of a given conditioner. A curve as follows can be obtained.



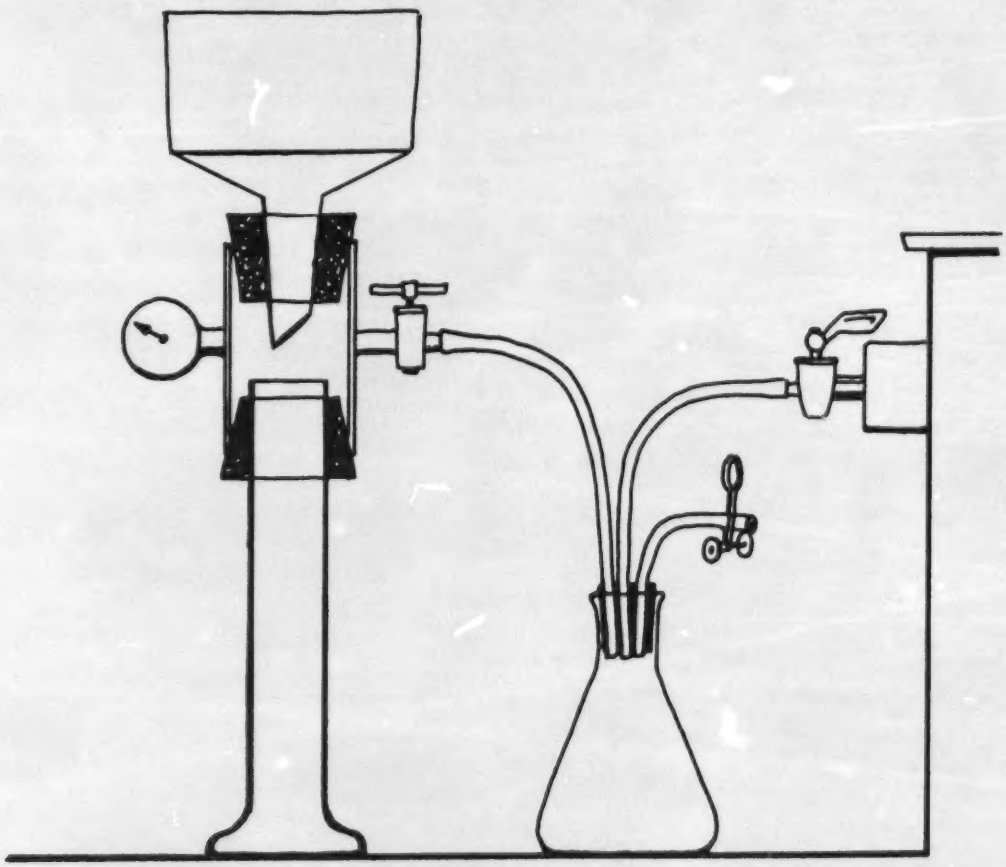
Using these curves optimum chemical dosages are found. In general, we can state that the lower the specific resistance the better filtrability of the sludge.

SUPPLEMENTARY MATERIALS

In order to calculate specific resistance the slope of the line of data plotting filtrate per time vs. time must be calculated. The following data must be collected and plotted: time/volume vs. volume of filtrate.

$$\text{Slope} = \frac{T/V}{V}$$

Determine slope by reading from the plotted data at some specific volume (V) the corresponding time/volume (T/V) value. Since the plot starts are zero - zero the fraction (T/V)/V is the slope of the line.



SPECIFIC RESISTANCE TEST APPARATUS

PERCENT SOLIDS

INTRODUCTION

In order to properly set pumping rates in a wastewater plant, operators must know how much water a given volume of sludge contains. The test is a modification of the total solids test.

EQUIPMENT

Porcelain evaporating dish - 100 ml or 200 ml
Balance - accurate to 0.1 g
Drying oven set at 103°C.
Steam table

PROCEDURE

1. CLEAN PORCELAIN DISH.

   Use acid cleaning solution and rubber gloves. Residues are difficult to remove and may have to be scrubbed out with steel wool. Wash in hot, soapy water and rinse thoroughly with final rinse in distilled water.

2. PLACE DISH IN 103°C. OVEN.

   Leave dishes in oven until ready to use.

3. USING DISH HOLDER, REMOVE DISH FROM OVEN.

   Allow it to cool on asbestos pad for 15 minutes.

4. WEIGH DISH.

   Weigh to nearest 0.1 g and record as dish weight.

5. MIX SLUDGE SAMPLE WITH GLASS ROD.

   Add well-mixed sample to dish until dish is 2/3 full.

6. RE-WEIGH DISH AND SAMPLE TO NEAREST 0.1 g.

   By subtracting, find weight of sample.

7. PLACE DISH ON STEAM TABLE.

Table should be producing steam before dish is placed in position. Remove two or three rings to allow dish to sit down in table. Make sure water is running through table and that the overflow tube is functioning. CAUTION: Do not let table run out of water or heating element may be burned out.

8. REMOVE DISH AND WEIGH.

After the water in the sample has evaporated, remove the dish, dry off the outside of the dish, and weigh to the nearest 0.1 g. Record as dish plus residue weight.

9. PLACE DISH IN ACID BATH TO SOAK.

CALCULATIONS

$$\% \text{ Solids} = \frac{\text{Residual weight}}{\text{Sample weight}} = 100$$

Example:

A. Dish weight = 112.5 g

B. Dish weight plus sample = 272.3 g

C. Dish weight plus residue = 126.2 g

Sample weight = (b - a) = 272.3 - 112.5 = 159.8 g

Residue weight = (c - a) = 126.2 - 112.5 = 13.7 g

$$\% \text{ Solids} = \frac{13.7 \text{ g}}{159.8 \text{ g}} \times 100$$

$$= 8.6\%$$

Specific Resistance Test Data

Sample Date_____ Analysis Date_____

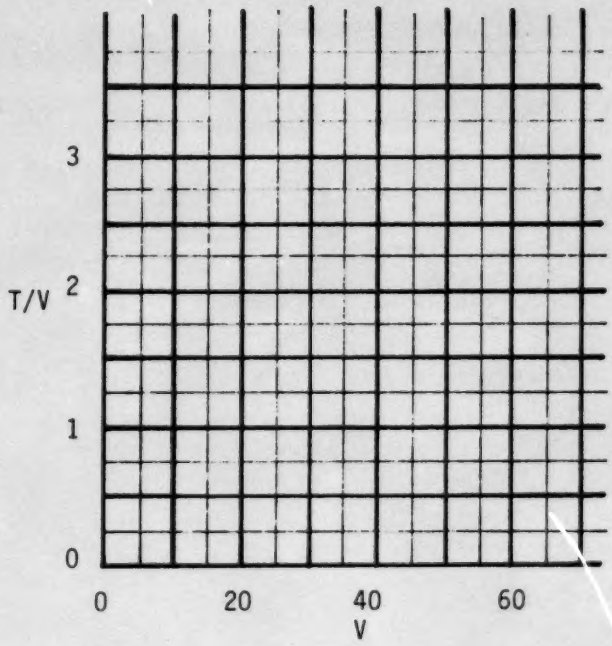
Sample Location_____ Lab Technician_____

Sludge Type_____ Conditioner:Type_____ Amount_____

CONDITIONED SLUDGE	
A) Wt. Dish plus Wet Sludge,g	
B) Wt. Dish plus Dry Sludge,g	
C) Wt. of Dish,g	
D) Wt. of Wet Sludge,g (A - C)	
E) Wt. of Dry Sludge,g (B - C)	
(Cs) % Solids in Sludge (E/D x 100)	
100 - Cs	

FILTER CAKE	
Sample Vol., ml	
F) Sample Wt.,g	
G) Wt. Filter plus Cake,g	
H) Wt. of Filter,g	
I) Wt. of Cake,g (G - H)	
(Cf) % solids in Cake (I/F x 100)	
100 - Cf	

T Time, sec	V Filtrate vol.ml	T/V
10		
20		
30		
40		
50		
60		



Slope $\frac{T/V}{V}$ = _____

$$\text{Specific Resistance} = \frac{\text{slope} \times 61{,}628{,}672}{\frac{1}{\frac{100 - Cs}{Cs} - \frac{100 - Cf}{Cf}}} = _____ \text{Sec}^2/\text{g}$$

SAMPLE DATA SHEET

SAMPLE IDENTIFICATION

Specific Resistance Test Data

CONDITIONER USED

Sample Date 10/10 Analysis Date 10/10

Sample Location WS Lab Technician RS

Sludge Type Waste A/S Contioner:Type Poly A Amount 1.5 mg/l

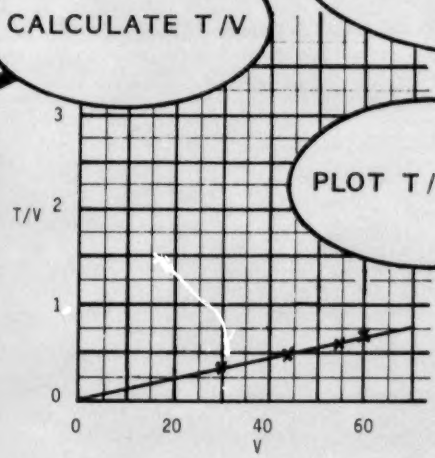
CONDITIONED SLUDGE		FILTER CAKE	
A) Wt. Dish plus Wet Sludge,g	192.4282	Sample Vol., ml	100 ml
B) Wt. Dish plus Dry Sludge,g	94.2533	F) Sample Wt.,g	100.0000
C) Wt. of Dish,g	88.0423	G) Wt. Filter plus Cake,g	27.1953
D) Wt. of Wet Sludge,g (A - C)	104.3859	H) Wt. of Filter,g	0.6093
Dry Sludge,g C)	6.2110	I) Wt. of Cake,g (G - H)	26
n Sludge 00)	5.95 %	(Cf) % solids in Cake (I/F x 100)	
	94.05 %	100 - Cf	

DATA AND CALCULATIONS NEEDED TO CALCULATE Cs

DATA AND CALCULATIONS NEEDED TO CALCULATE Cf

CALCULATE T/V

T Time, sec	V Filtrate vol.ml	T/V
10	30.0	0.32
20	42.0	0.48
30	47.0	0.64
40	60.0	0.68



PLOT T/V VS. V

RECORD TIME VS. VOLUME HERE

CALCULATE SLOPE

Slope $\frac{T/V}{V}$ = 0.0136

$$\text{Specific Resistance} = \frac{\text{slope} \times 61{,}628{,}672}{\frac{1}{\frac{100 - Cs}{Cs} - \frac{100 - Cf}{Cf}}} = 10^7 \text{ Sec}^2/\text{g}$$

FINAL RESULTS

PROCEDURE SUMMARY

PROCEDURE

1. Weigh prepared filters.
2. Place funnel on collar.
3. Instert filter.
4. Seat filter.
5. Measure sample.
6. Add sample and start timer.
7. Measure filtrate vs. time.
8. Measure time for cake to crack.
9. Weigh filter plus cake.
10. Record data.
11. Perform calculations.

CALCULATIONS:

Values Needed:

$$\text{Slope} = \frac{T/V}{V}$$

(Cs)% Solids in Sludge

(Cf)% Solids in Cake

Specific Resistance =

$$\frac{\dfrac{\text{Slope} \times 61{,}628{,}672}{1}}{\dfrac{100 - Cs}{Cs} - \dfrac{100 - Cf}{Cf}}$$

Specific Resistance

The above procedure summary is designed as a laboratory aid. It may be cut out and attached to a 5" X 7" index card for convenient reference at the laboratory bench. To protect the card you may wish to cover it, front and back, with clear, self-adhesive shelf paper or similar material.

SPECIFIC RESISTANCE TEST

WORKSHEET

Directions: Place an "X" by the best answer. There is only one best answer for each question.

1. The major purpose for the specific resistance test is to:

   a)_____ determine SVI.

   b)_____ measure filterability of sludge.

   c)_____ determine decant time.

   d)_____ None of the above.

   e)_____ All of the above.

2. Calculation of slope:

   a)_____ has no bearing in the calculation of specific resistance.

   b)_____ is the relationship of time/volume per volume.

   c)_____ is a function of cake solids.

   d)_____ None of the above.

   e)_____ All of the above.

3. Calculation of slope:

   a)_____ is necessary for the calculation of specific resistance.

   b)_____ is necessary for the calculation of percent moisture.

   c)_____ is necessary in the calculation of percent solids.

   d)_____ None of the above.

   e)_____ All of the above.

4. In general, it can be stated that the faster a sludge dewaters:

   a)_____ the lower the solids concentration.

   b)_____ the higher the solids concentration.

   c)_____ the better the filterability of the sludge.

   d)_____ None of the above.

   e)_____ All of the above.

5. When running a specific resistance test:

a)_____ the time interval is 30 seconds.

b)_____ the time interval is one hour.

c)_____ time has no bearing except to determine slope.

d)_____ None of the above.

e)_____ All of the above.

6. Specific resistance test results are given in:

a)_____ cc/l.

b)_____ ppm.

c)_____ mg/l.

d)_____ Sec^2/g.

e)_____ mg/g.